INTERANNUAL DIFFERENCES IN PHYTOPLANKTON SEASONAL CYCLES IN SARONIKOS GULF

K. PAGOU

National Center for Marine Research, Aghios Kosmas, Hellinikon, Greece

The originally oligotrophic waters of the Saronikos Gulf have been locally submitted to eutrophication due to a continuous input of nutrient-rich sewage from urban and industrial origin. Hence the former seasonal phytoplankton cycle (IGNATIADES, 1969) has been affected. This study considers the effects of the effluents on both the algal abundance and distribution (chl. *a*) and on the annual cycle (FRILIGOS, 1985; PAGOU and IGNATIADES, 1988). Monthly samplings (April 1982 to March 1983 and April 1989 to March 1990) were done at 1 m depth (Niskin bottles) at two stations : S1 in an eutrophic environment (sewage from Athens) and S2 in an almost oligotrophic area. Different parameters were determined (see Table 1). A similarity matrix using the Bray-Curtis measure of similarity on log (x+1) data of the main phytoplankton groups abundance was subjected to MDS analysis (KLARKE and GREEN, 1988). Although temperature and salinity values did not differ between stations, the ranges and mean values of nutrients (Table 1) confirmed the eutrophic character of station S1 in relation to S2, for both sampling periods. The results from the chlorophyll *a* and phytoplankton cell data showed that the eutrophic environment promoted the growth of phytoplankton (Table 1) for both periods. However, differences on phytoplankton parameters values occurred mainly in the eutrophic area (S1) between the two sampling periods. During 1982-1983 exceptionally high concentrations of chlorophyll *a* and phytoplankton cells were recorded at station S1 in comparison to values either from the same station during 1989-90, or from station S2 for both years. These differences can be attributed to the lower values of nutrients (NO_3-N, PO^{-3}_4-P, Table 1) recorded during 1989-90 at the eutrophic station S1, caused rather from the unstable character of this eutrophic environment, than from a better control of the effluents.

Station	Temperature (°C)	Salinity (ppt)	DO ml(/l)	NO^-_3-N (µg-at/l)	PO^{-3}_4-P (µg-at/l)	Chl-*a* (µg/l)	Total cells (cells/l)
A. April 1982 - March 1983							
S_1	12.90-26.00 18.98	36.67-38.69 37.44	2.75-7.21 4.33	0.07-6.13 1.94	0.05-4.20 1.37	0.10-84.25 12.19	$2.9X10^4$-$1.9X10^7$ $3.1X10^6$
S_2	12.80-25.2 18.81	36.69-38.49 37.51	2.80-6.11 4.69	0.18-1.54 0.59	0.05-0.27 0.13	0.10-2.17 0.51	$4.0X10^3$-$2.4X10^5$ $4.5X10^4$
B. April 1989 - March 1990							
S_1	13.61-24.87 18.82	37.49-38.73 38.23	3.98-5.96 5.05	0.17-1.24 0.59	0.03-4.53 0.84	0.31-9.35 2.85	$2.2X10^4$-$7.0X10^5$ $4.0X10^5$
S_2	13.93-25.14 19.29	38.22-38.72 38.46	4.60-5.83 5.21	0.10-0.49 0.27	0.03-0.76 0.14	0.10-1.66 0.61	$8.8X10^3$-$3.0X10^6$ $8.3X10^5$

Table 1. Range and mean values of selected hydrographic and biological parameters in 1m depth of Saronikos Gulf, during the periods April 1982-March 1983 (PAGOU and IGNATIADES, 1988; PAGOU, unpublished data) and April 1989 -March 1990 (NCMR, 1991).

The annual cycles of chlorophyll *a* (Fig. 1) have been altered from the pattern previously described and maxima were recorded in summer (June), at the eutrophic station S1, during both sampling periods, whereas at station S2, maxima were recorded both during spring (March 1983, 1990) and summer (June 1983). From the above presented and discussed data, it is obvious that differences had occurred, concerning the annual cycles of phytoplankton between stations and sampling periods. Thus numerical taxonomy (MDS - stress : 0.130, Fig. 2) was used in order to assess whether these differences are significant and to test if a seasonal grouping of the phytoplankton samples exists, according to the presence and abundance of phytoplankton groups. At the similarity level of 70% two groups were distin-guished (Fig. 2): a) Group 1 consisted only from some 1982-83 samples from both stations, i.e. autumn samples (August, September, October 1982) from station S1 and various sam-ples from station S2, originating throughout the first sampling period (April, May, June, July, September, October, November, December 1982). The samples of group 1 were characterized by low abundances of µ-flagellates and "others" and intermediate of all other groups. b) Group 2 was con-structed from all the remaining samples from the first period and the samples from 1989-90. However in group 2, two well defined subgroups could be described. The first subgroup (2A) joined samples from spring to late summer, from both stations and sampling periods (S1: June, July 1982, April, June, September 1989, March 1990, S2: April, September 1989), having as dominant groups mostly dinofla-gellates and µ-flagellates. Mainly winter samples (S1: December 1989, S2: January February 1983, June, December 1989) were contributing to the formation of the second subgroup (2B) and were characterized by almost equal predominance of diatoms, dinoflagellates and coccolitho-phorides, along with relatively high abundances of µ–flagellates and "others". The conclusion that could be drawn from the above data analysis, for both sampling periods, is that discrepancies have been occurred on the seasonal cycles of phytoplankton groups in both eutrophic and oligotrophic areas, which have altered the succession pattern of phytoplankton, although in different ways for each period. This conclusion is in agreement with the hypothesis that though phytoplankton community responds to changes in the physicochemical environment, other factors such as climatological changes can also act as a "stress" factor on the ecosystem, and pollution alone cannot explain the observed differences (GREVE and PARSONS, 1977).

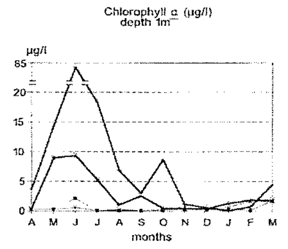

Fig. 1. Annual cycles of chl *a* (mg/l, 1 m depth)

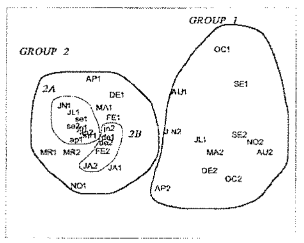

Fig. 2. MDS plot of phytoplankton samples (stress: 0.130). **Symbols:** upper case letters = months of 1982-83, lower case letters = months of 1989-90, 1 = station S1, 2 = station S2.

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SEASONAL VARIABILITY OF NANO- AND MICROPLANKTON IN HERAKLION BAY (SOUTH AEGEAN)

Paraskevi PITTA[1] and Antonia GIANNAKOUROU[2]

[1] Institute of Marine Biology of Crete, P.O. Box 2214, 710 03 Heraklion, Greece

[2] Station de Biologie Marine, 34200 Sète, France

Plankton community dynamics, in the Eastern Mediterranean, and especially as far as microzooplankton is concerned, has hardly been studied. A regular sampling programme was undertaken in order to study the structure of the nano- and microplankton communities in the Gulf of Heraklion over four distinct periods as well as the intra-annual differences in species composition. To this end, samples were collected between 15/1 and 26/2/1992 (winter), 17/4 and 19/5/1993 (spring), 1/6 and 3/7/1993 (summer), 4/11 and 6/12/1993 (autumn). Sampling was conducted on the surface layer of the coastal sea area every fourth day, using a 10 l recipient. The samples were preserved with acidic Lugol's iodine and stored at 4°C until examination under an inverted microscope. Counts and identification of planktonic organisms (diatoms, flagellates, dinoflagellates, ciliates and rotifers) were carried out with the Utermöhl method, to the species level. These data were analysed using Multi-dimensional scaling (MDS) (FIELD *et al.*, 1982) with a log(x+1) transformation and Canberra similarity index. The two dimensional MDS plot (Fig.1) reveals a pattern corresponding to seasonal differences in the structure of plankton communities. It can clearly be seen that winter and autumn samples form two separate clusters while spring and summer communities are grouped together in a third cluster. The high community similarity between spring and summer can be attributed to the similar environmental conditions (light intensity, temperature, nutrients concentration) during this period. Figure 2 shows the quantitative data at the group level, i.e. the average abundance as well as the total species number of diatoms, dinoflagellates, ciliates and rotifers. Flagellates are not included in this histogram because their enumeration was based on size classes. It is apparent that at this group level three combinations are distinguished: high diatom-low dinoflagellate (winter), low diatom-high dinoflagellate (spring-summer) and low diatom-moderate dinoflagellate (autumn). In comparison to the above mentioned groups, ciliates are of minor quantitative importance although they present a noticeable species richness. Diatoms presented maximal abundance in winter samples (highest value 13 480 cells/l) with dominant species *Nitzschia delicatissima, N. seriata* and *Leptocylindrus danicus*. Dinoflagellates were particularly abundant in spring and summer (maximal abundance 10 340 cells/l and 7 640 cells/l respectively) and less abundant in autumn (4 280 cells/l max. value). The highest density (592 000 cells/l), recorded in a summer sample, was monopolized by a *Peridinium trochoideum* bloom. Two rotifer species (*Synchaeta triophthalma* and *Trichocerca sp.*) were found. Rotifers' abundance was detectable only during spring and summer. The highest density counted was 780 *S. triophthalma*/l in a summer sample while the usual abundance, during spring and summer was 20 ind./l. Overall, 30 plankton ciliate species were identified: 10 Tintinnina and 20 Oligotrichina species. Ciliates presented a higher number of species in spring and summer while their maximal abundance was recorded during summer. The dominant ciliate species were *Strombidium conicum, S. parvum, S. vestitum, Favella azorica* and a tiny *Strombidium sp.* In comparison to seasonal phytoplankton data from Saronikos Gulf (IGNATIADES, 1969) our data presen-ted higher abundance of dinoflagellates and less pronounced seasonal differences in diatoms abundance as well as qualitative differences in phytoplankton community composition. These differences might be related to the proximity of Crete to the subtropical zone as well as to the fact that in the near shore zone, the fluctuation of nutrients throughout the year is less dramatic than in more offshore systems.

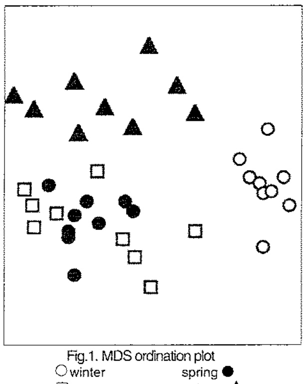

Fig.1. MDS ordination plot
○ winter spring ●
□ summer autumn ▲

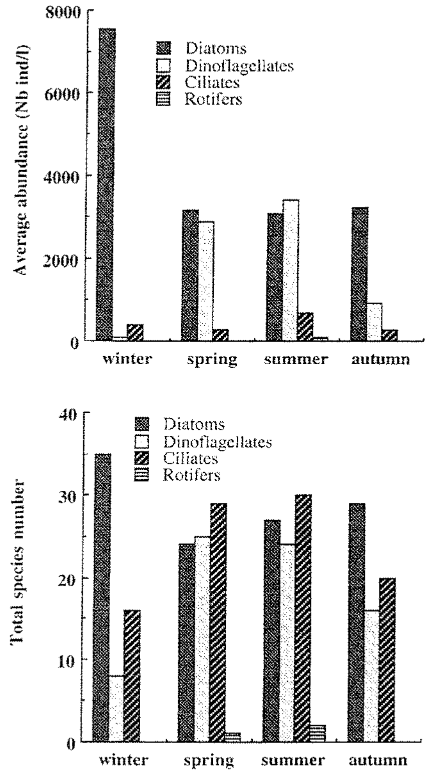

Fig. 2. Average abundance (in all 9 samples) and total species number (over 9 samples) of plankton groups over the four seasons.

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